

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to the field of signal transmission in optical communication networks.

[0002] Recent evolutions of the optical networks mainly concern the development of transparent or semi-transparent networks. Transparent networks refer to networks where signal transmission is achieved in the optical domain along the entire path. This type of networks allows to reduce the number of optoelectronic devices required for signal regeneration and therefore reduces the global cost of the network. Nevertheless, in order to ensure connectivity while optimizing network resources in transparent networks, signal settings such as signal wavelength, bit rate or modulation rate need to be optimized.

EP 1 585 237 offers a method to convert a Differential Phased Shift Keying (DPSK) signal into a Phase Shaped Binary Transmission (PSBT) signal thanks to the use of a module comprising an optical delay filter.

SUMMARY OF THE INVENTION

[0003] One object of the present invention is to provide agile elements capable of modifying transmission signal settings, especially to provide modulation format flexibility. Another object of the invention is to offer an inexpensive way to adjust signal modulation formats.

[0004] This adjustment is achieved by a method for optimizing signal transmission in an optical network wherein the transfer function of a filtering component is selectively configured in order to adapt signals modulation format to the transmission requirements.

[0005] Preferably, said filtering component comprises Wavelength Selective Switches (WSSs) based on Liquid Crystal on Silicon (LCOS) switching elements.

[0006] Advantageously, the transmission requirements comprise the available bandwidth along the path, the required bit-rate, the length of the path.

[0007] Preferably, the modulation formats comprise a Phase Shaped Binary Transmission (PSBT) format and a Differential Phased Shift Keying (DPSK) format.

[0008] Advantageously, the input signal of the Wavelength Selective Switches (WSSs) based on Liquid Crystal on Silicon (LCOS) switching elements has a Differential Phased Shift Keying (DPSK) format and the output signal of the Wavelength Selective Switches (WSSs) based on Liquid Crystal on Silicon (LCOS) switching elements has either a Differential Phased Shift Keying (DPSK) or a Phase Shaped Binary Transmission (PSBT) format depending on the selected filtering transfer function.

[0009] Alternatively, the Wavelength Selective Switches (WSSs) based on Liquid Crystal on Silicon (LCOS) switching elements are used not only to produce modulation format agility but also to perform the wavelength multiplexing between the different Wavelength Division

Multiplexing (WDM) channels.

[0010] Furthermore, optical device comprising a filtering transfer function characterized in that said filtering transfer function is used to select a modulation format.

[0011] Alternatively, the modulation formats comprise a Phase Shaped Binary Transmission (PSBT) format and a Differential Phased Shift Keying (DPSK) format.

[0012] Preferably, said optical device comprises Wavelength Selective Switches (WSSs) based on Liquid Crystal on Silicon (LCOS) switching element.

[0013] Advantageously, the input signal of the Wavelength Selective Switches (WSSs) has a Differential Phased Shift Keying (DPSK) format and the output signal of the Wavelength Selective Switches (WSSs) is either a Differential Phased Shift Keying (DPSK) or a Phase Shaped Binary Transmission (PSBT) format depending on the selected filtering transfer function.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

FIG.1 is a diagram of a network cross-connect;

DETAILED DESCRIPTION OF THE INVENTION

[0015] As used herein, the term "ingress node" refers to the source network node where the optical signal is created and transmitted to the network optical fibers.

[0016] As used herein, the term "egress node" refers to the destination network node where the optical signal is received and converted to electrical signal in order to be processed.

[0017] The present invention refers to a method for adjusting the modulation rate of an optical signal allowing a higher flexibility of the network. In a transparent optical network such adjustment is needed at the ingress node to optimize signal transmission according to the requested connection. The idea is to use an optical filtering component allowing the modification of its transfer function in order to provide modulation format agility. One way to achieve this goal is to use Liquid Crystal on Silicon Wavelength Selective Switches (LCOS-WSSs). Such switches are commercially available from Engana Pty Ltd, Australia and their detailed description of structure and functioning is given in the patents WO2006/034533 and WO2005/047942. In these switches, the application of an electric current produces a change of orientation of the liquid crystal molecules and therefore a modification of the refraction index of the material. Thus, the selection of a suitable refraction index allows the selection of the reflected wavelength. In an embodiment, the present invention uses the filtering properties of the liquid crystal for modulation format selection. In addition, it may be used simultaneously for wavelength selective switching functions. LCOS-WSSs being already implemented in optical networks, this embodiment offers a cost-reduced way to realize modulation format agility. Said LCOS-

WSSs are located in network cross-connects.

[0018] To better understand an embodiment of the invention, Fig.1 represents a network cross-connect located in a network node. Optical signals coming from other nodes are received through input fibers 1 of the cross-connect element. These input signals are either converted to electrical signal and processed if the current node is their egress node or transmitted to an output fiber 9 thanks to a patch panel 7. A request can also be made to current node to establish a connection with a remote node. In this case, the optimal path is determined by a "control plane" entity. This determination is made in function of the request features (length of the selected path, requested bitrate...), the network availability and the adjustable transmission parameters (channel wavelength...). Said adjustable transmission parameters provide network flexibility and allow increasing network capabilities. The present invention offers to use a feature of the LCOS-WSSs 5 to adjust the modulation format of the emitted optical signal. This feature refers to the possibility to modify the filtering transfer function of said LCOS-WSS 5.

[0019] On Fig.1, the signals needed to be sent by the electrical router 3 are converted to optical signals by transmitters (Tx) comprising laser sources and transmitted to the LCOS-WSS 5. Said optical signals received by the LCOS-WSSs 5 have originally a Differential Phased Shift Keying (DPSK) modulation format. Due to the filtering agility of the liquid crystal matrix, said WSSs can either transmit optical signals keeping the same modulation format or convert said optical signal to a Phase Shaped Binary Transmission (PSBT) modulation format by applying a delay filter or a filter configured to approximate the delay filter known in the prior art, e.g. in the form of a second order Gaussian filter. The DPSK format allows a longer transparent transmission but requires a larger spectral bandwidth than the PSBT format. Thus, in function of the features of the selected path, the electrical router adjusts the LCOS-WSS configuration to be optimal.

At the output of the LCOS-WSSs, optical signal having either a PSBT or a DPSK modulation format are sent to the optical patch panel 7 to be oriented and transmitted to an output fiber 9. Said signals are then transmitted through the network to their egress nodes.

[0020] Thus, the present embodiment uses the filtering-agility feature of the LCOS-WSS to allow modulation rate format selection. This new application of an existing network component increases network flexibility and capacity without increasing cost. Moreover, it solves the problem of finding the fair ratio of DPSK and PSBT transceivers to be installed at the beginning of life of the network to meet future evolutions of the demands.

Claims

1. Method for optimizing signal transmission in an op-

tical network **characterized in that** the transfer function of a filtering component is selectively configured in order to adapt signals modulation format to the transmission requirements.

2. Method for optimizing signal transmission in an optical network according to claim 1 **characterized in that** said filtering component comprises Wavelength Selective Switches (WSSs) based on Liquid Crystal on Silicon (LCOS) switching elements.
3. Method for optimizing signal transmission in optical network in accordance with claim 1 or 2, **characterized in that** the transmission requirements comprise the available bandwidth along the path, the required bit-rate, the length of the path.
4. Method for optimizing signal transmission in optical network in accordance with one of the previous claims, **characterized in that** the modulation formats comprise a Phase Shaped Binary Transmission (PSBT) format and a Differential Phased Shift Keying (DPSK) format.
5. Method for optimizing signal transmission in optical network in accordance with claim 2 and 4, **characterized in that** the input signal of the Wavelength Selective Switches (WSSs) based on Liquid Crystal on Silicon (LCOS) switching elements has a Differential Phased Shift Keying (DPSK) format and the output signal of the Wavelength Selective Switches (WSSs) based on Liquid Crystal on Silicon (LCOS) switching elements has either a Differential Phased Shift Keying (DPSK) or a Phase Shaped Binary Transmission (PSBT) format depending on the selected filtering transfer function.
6. Method for optimizing signal transmission in optical network in accordance with claim 5 **characterized in that** the Wavelength Selective Switches (WSSs) based on Liquid Crystal on Silicon (LCOS) switching elements are used simultaneously to produce modulation format agility and to perform the wavelength multiplexing between the different Wavelength Division Multiplexing (WDM) channels.
7. Optical device comprising a filtering transfer function **characterized in that** the optical device is configured in a way that said filtering transfer function allows to select a modulation format.
8. Optical device comprising a filtering transfer function in accordance with claim 7 **characterized in that** the modulation formats comprise a Phase Shaped Binary Transmission (PSBT) format and a Differential Phased Shift Keying (DPSK) format.
9. Optical device comprising a filtering transfer function

in accordance with claim 7 or 8 **characterized in that** said optical device comprises Wavelength Selective Switches (WSSs) based on Liquid Crystal on Silicon (LCOS) switching element.

10. Optical device comprising a filtering transfer function in accordance with claim 9 **characterized in that** the at least one input of the Wavelength Selective Switches (WSSs) is configured to receive a Differential Phased Shift Keying (DPSK) format and the at least one output of the Wavelength Selective Switches (WSSs) is configured, depending on the selected filtering transfer function, to output either a Differential Phased Shift Keying (DPSK) or a Phase Shaped Binary Transmission (PSBT) format.

Amended claims in accordance with Rule 137(2) EPC.

1. Method for optimizing signal transmission in an optical network **characterized in that** the transfer function of a filtering component is selectively configured in order to adapt signals modulation format to the transmission requirements, said filtering component comprising Wavelength Selective Switches (WSSs) based on Liquid Crystal on Silicon (LCOS) switching elements.

2. Method for optimizing signal transmission in optical network in accordance with claim 1, **characterized in that** the transmission requirements comprise the available bandwidth along the path, the required bit-rate, the length of the path.

3. Method for optimizing signal transmission in optical network in accordance with one of the previous claims, **characterized in that** the modulation formats comprise a Phase Shaped Binary Transmission (PSBT) format and a Differential Phased Shift Keying (DPSK) format.

4. Method for optimizing signal transmission in optical network in accordance with claim 3, **characterized in that** the input signal of the Wavelength Selective Switches (WSSs) based on Liquid Crystal on Silicon (LCOS) switching elements has a Differential Phased Shift Keying (DPSK) format and the output signal of the Wavelength Selective Switches (WSSs) based on Liquid Crystal on Silicon (LCOS) switching elements has either a Differential Phased Shift Keying (DPSK) or a Phase Shaped Binary Transmission (PSBT) format depending on the selected filtering transfer function.

5. Method for optimizing signal transmission in optical network in accordance with claim 4 **characterized in that** the Wavelength Selective Switches

(WSSs) based on Liquid Crystal on Silicon (LCOS) switching elements are used simultaneously to produce modulation format agility and to perform the wavelength multiplexing between the different Wavelength Division Multiplexing (WDM) channels.

6. Optical device comprising a filtering transfer function **characterized in that** said optical device comprises Wavelength Selective Switches (WSSs) based on Liquid Crystal on Silicon (LCOS) switching element and that said optical device is configured in a way that said filtering transfer function allows to select a modulation format.

7. Optical device comprising a filtering transfer function in accordance with claim 6 **characterized in that** the modulation formats comprise a Phase Shaped Binary Transmission (PSBT) format and a Differential Phased Shift Keying (DPSK) format.

8. Optical device comprising a filtering transfer function in accordance with claim 7 **characterized in that** the at least one input of the Wavelength Selective Switches (WSSs) is configured to receive a Differential Phased Shift Keying (DPSK) format and the at least one output of the Wavelength Selective Switches (WSSs) is configured, depending on the selected filtering transfer function, to output either a Differential Phased Shift Keying (DPSK) or a Phase Shaped Binary Transmission (PSBT) format.

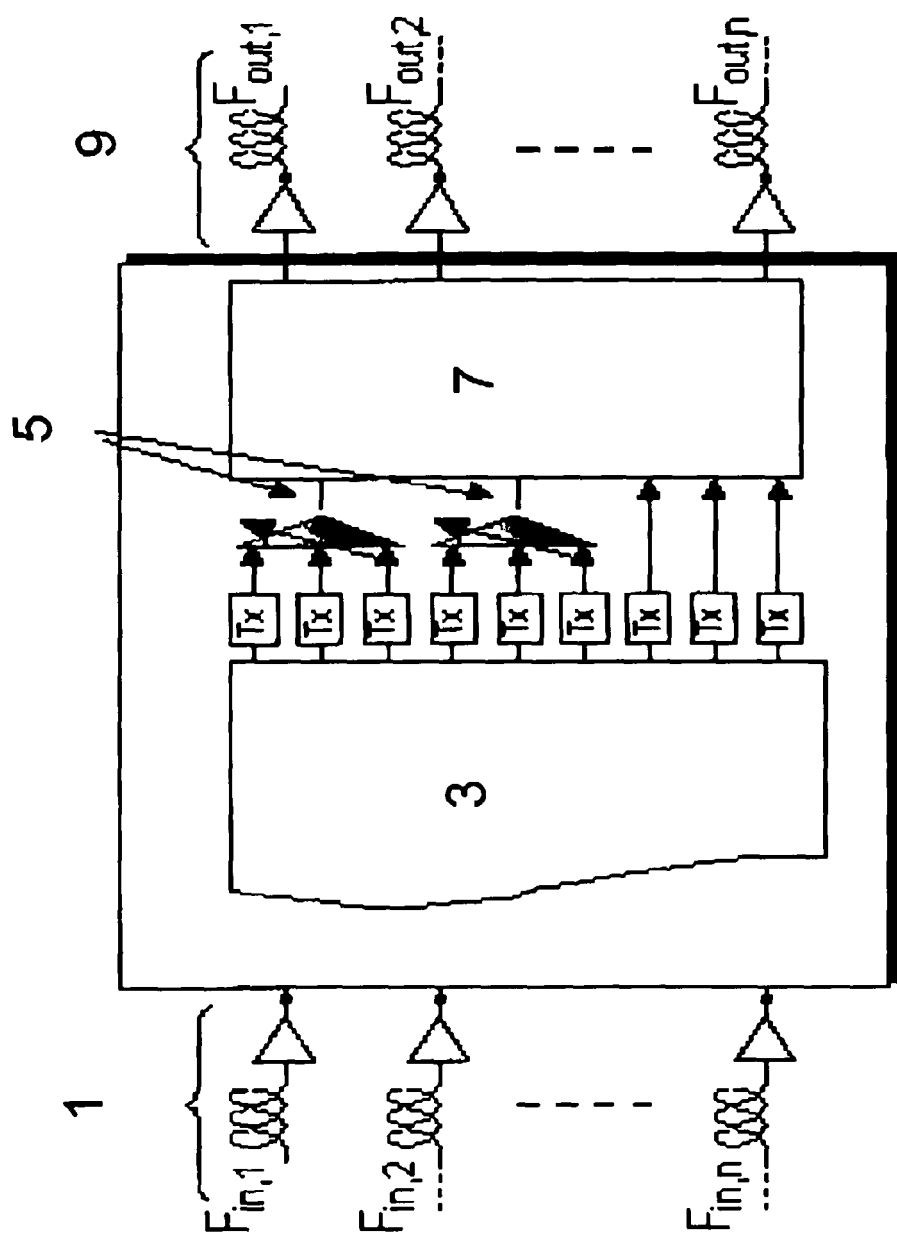


Fig.1



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 08 29 0097

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2007/183791 A1 (ROSSETTI DAMIANO [IT] ET AL) 9 August 2007 (2007-08-09) * page 1, paragraph 5 - paragraph 17 * * paragraph [0035]; claims 1-3; figures 2,3 *	1,3,4,7,8	INV. H04B10/155
X	EP 1 585 237 A (CIT ALCATEL [FR]) 12 October 2005 (2005-10-12) * the whole document *	1,3,4,7,8	
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Y	EP 1 832 914 A (TECDIA CO LTD [JP]) 12 September 2007 (2007-09-12) * abstract; figure 2 *	2,9	
X	WO 2007/103669 A (FINISAR CORP [US]; DENG HONGYU [US]; VANDYSHEV YURI [US]) 13 September 2007 (2007-09-13) * page 3, line 25 - line 28 * * page 9, line 4 - page 10, line 29 * * claim 3; figure 3 *	1,7 2-6,8-10	
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			TECHNICAL FIELDS SEARCHED (IPC)
			H04B G02B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 25 July 2008	Examiner Koch, Bernhard
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 08 29 0097

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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25-07-2008

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US 2007183791 A1	09-08-2007	NONE	
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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 1585237 A [0002]
- WO 2006034533 A [0017]
- WO 2005047942 A [0017]